SOME FACTS ABOUT MALARIA

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MALARIAL FEVER is a disease which is carried from the sick to the healthy by certain kinds of mosquitoes known as "anopheles" or "anophelines."

These anopheles mosquitoes are distinguished from most other mosquitoes of the United States by the fact that their wings are more or less spotted, and that in resting on the wall their bodies incline away from the wall at an angle, while with most others the body is parallel to the wall. The female mosquitoes also have palpi (mouth feelers) which are nearly as long as the beak.

This bulletin gives a brief account of the disease and of the microscopic parasite which causes it, tells how persons become infected, describes the life and habits of the principal mosquitoes which carry the disease in the United States, and shows how it can be stamped out and persons cured who have been so unfortunate as to contract it.

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MOSQUITOES NOT MERELY A NUISANCE.

It is a noticeable fact that in most parts of the world where anti-mosquito measures have been undertaken on a large scale the work has been done with the direct end of doing away with mosquito-borne diseases. In the United States, however, little direct antimalarial work was done until we entered the great war, when the Medical Department of the Army took up this work in the great cantonments and the United States Public Health Service endeavored to control the malarial mosquitoes in the areas bordering the camps.

There are, however, many other localities in the United States where malaria is prevalent, and some in which the existence of the disease in an aggravated form is a serious barrier to agricultural or industrial development. It has been shown, for example, that, agriculturally speaking, the lands of the Delta region of Mississippi and adjoining States are the richest in the whole world, with the possible exception of the delta of the Nile, and yet, on account of the extraordinary prevalence of malaria in this region, it is sparsely settled and land prices are low. The advance of the cotton-boll weevil into this section has had its customary effect of driving a considerable proportion of the negro labor into other regions not yet invaded, and unless the country is to become impoverished it will be necessary to import white labor. Negroes are more or less resistant to malaria, but this will not be true of the white labor coming into this region, which will undoubtedly become rapidly infected with the disease.

Malaria is not a difficult disease to fight. This has been shown in many parts of the world—in Italy, in Cuba, in Panama, in West Africa, in India, in Egypt, and elsewhere. People, generally, should know the exact truth about the disease and what is to be done. The efforts of individuals, after they have acquired the proper knowledge, will have an effect upon the malaria rate, while with a general knowledge of these facts community work must come sooner or later.

In the pages which follow, the statements regarding the disease itself are partly drawn, with the permission of the American pub-

lishers, from an admirable summary prepared by Dr. Ronald Ross,[1] of the Liverpool School of Tropical Medicine, who was the first discoverer of the relation between malaria and mosquitoes, something over 20 years ago, in India. His results were soon confirmed by workers in many parts of the world, and the statements here made are accepted by the best physicians of all countries.

THE DISEASE AND ITS CAUSE.

The disease known as malaria, or fever and ague, or chills and fever, or marsh fever, and the varieties called intermittent fever, remittent fever, and pernicious fever, are caused by parasites in the blood which feed upon the red blood cells.

Malaria occurs more or less in all warm climates, especially in the summer after rains and near marshy ground. It is said to cause one-fourth or more of all the sickness in the Tropics.

The parasites in the blood are microscopic one-celled animals called plasmodia.

These minute parasites are introduced into the blood through the proboscis of certain mosquitoes of the genus Anopheles.

On being introduced in this way, each parasite enters one of the red blood cells, in which it lives and grows.

When full grown, each parasite divides and thus produces a number of spores, which escape from the blood cell and enter fresh cells. This method of propagation may continue for years.

Although only a few of the parasites may have been introduced originally through the beak of the mosquito, they rapidly increase until millions upon millions of them may exist in the blood.

At first, when the number of parasites is still small, an infected person may remain apparently well. When, however, the number is large enough, he begins to suffer from fever.

The parasites tend to produce their spores all at the same time, and it is at the moment when these spores escape from the blood cells, almost simultaneously, that the fever begins.

The fever is probably caused by a little poison which escapes from each parasite with the spores.

After from 6 to 40 hours or more this poison is eliminated from the patient's system and his fever tends to leave him.

In the meantime, however, a new generation of parasites from the spores is approaching maturity; and when this is reached they in their turn break up and cause another attack of fever like the first, and so on indefinitely for months and months. In this way the attacks of the fever follow each other at regular intervals.

But it often happens, as the result of repeated infections, that a new attack has commenced before the former one has ceased, so that they overlap and the fever continues.

[1] See Ronald Ross, The Prevention of Malaria. London, John Murray; New York, E. P. Dutton & Co.

After a time, even without treatment, the number of parasites may decrease until not enough of them are left to produce fever, in which case the patient improves temporarily.

It generally happens, however, sooner or later, that the number of parasites increases again, and the patient again suffers from a series of attacks.

Such relapses are frequently encouraged by fatigue, heat, chill, wetting, dissipation, or illness, and they may occur at intervals for a long time after the patient was first infected by the mosquito, and even after he has moved to localities where there is no malaria.

Besides fever, these malarial parasites often produce anemia and enlargement of the spleen, especially with patients who have suffered many relapses.

Death is often caused in malarial patients by other diseases, such as pneumonia or dysentery, the system being already weakened by the malarial parasites.

If the patient survives, the parasites tend to die out of themselves, without treatment, after a long period of illness, leaving him more or less immune.

The parasites are of at least three kinds, which can be easily distinguished in the blood if placed under the microscope. These are (1) a parasite which produces its spores every three days and causes what is called quartan fever; (2) a parasite which produces its spores every other day and causes tertian fever; (3) parasites which cause the so-called malignant fever or pernicious malaria, which is of an irregular type and in which dangerous complications most frequently occur.

Quinine kills the parasites when administered at the proper time; but generally it will not destroy all the parasites in the body unless it is given in sufficient doses and continued for several months. As long as a single parasite remains alive in the blood, the patient may be subject to relapses. Ross advises that at least 5 grains of sulphate of quinine should be taken by an adult patient every day without fail for four months, but he should consult a physician regarding the details of the treatment.

HOW MALARIA SPREADS.

The malaria parasite has several different stages. Aside from those forms which produce spores in the body, there are other stages—male and female. When one of these anopheline mosquitoes, which carries malaria, happens to feed on a patient whose blood contains parasites, these are sucked, with the blood, into the mosquito's stomach.

If the sexual forms of the parasites are present, those of opposite sexes at once unite. The parasite now undergoes certain changes in

the mosquito's stomach. It passes through the stomach wall and finally affixes itself to its outer surface.

Here it grows very considerably and, after a week under favorable conditions, produces a large number of spores.

These spores, thus entering the general body cavity of the mosquito, find their way into the salivary glands. These glands secrete the irritating fluid injected under the human skin when the mosquito begins to feed.

Thus, when one of these mosquitoes, which has fed upon a malarial patient containing the sexual forms of the parasites, bites, after a week, another person, it injects these spores together with its saliva under his skin and generally into his blood.

These spores now cause or may cause infection or reinfection in this second person.

Thus the parasites of malaria pass from men to certain mosquitoes and back from these mosquitoes to men.

Malarial fever is then an infectious disease, which is carried from the sick to the healthy by anopheline mosquitoes, and only in this way can it be contracted.

It has always been known that malaria is most prevalent in the vicinity of marshes, and it was formerly supposed that the air or exhalations from these marshes produced the disease. Parasites of malaria have not been found in the water or air of marshes, nor in decaying vegetation, nor in the soil, although they have been diligently searched for. Attempts to produce infection by these agencies have always failed. The mosquitoes which carry these parasites, however, breed in marshes or in marshy pools and streams.

Issuing from these breeding places, they enter near-by houses and feed upon the inmates, mostly at night, biting first one person and then others, and living for weeks or months.

If an infected person happens to be present in any of these houses, the anopheline mosquitoes biting him will also become infected, and the disease is likely, ultimately, to be carried by these mosquitoes to others and to neighboring houses.

Thus a whole neighborhood soon becomes infected and the locality is called malarious. In such localities it is easy to find the parasites of malaria in the proper mosquitoes. Sometimes 25 per cent or more of them are found to be infected.

In malarious localities the anopheline mosquitoes bite the healthy new-born children and infect many of them.

Such children if not thoroughly treated may remain infected for years. They may become anemic and possess enlarged spleens, and of course may spread the infection to others.

In malarious localities almost every child has been found to contain the parasites of malaria or to possess an enlarged spleen.

In such a locality, therefore, the infection is constantly passed on by means of the mosquitoes from the older children or from adults to the newly born infants, so that the locality may remain malarious for very many years, in fact indefinitely.

In the same way a newcomer arriving in such a locality will very probably become infected, especially if he sleeps in an infected house, even for one night, at a time when mosquitoes are flying and biting. A locality is malarious only when it contains persons infected with the parasites, and also sufficient numbers of the proper species of mosquitoes to carry the infection to the healthy persons.

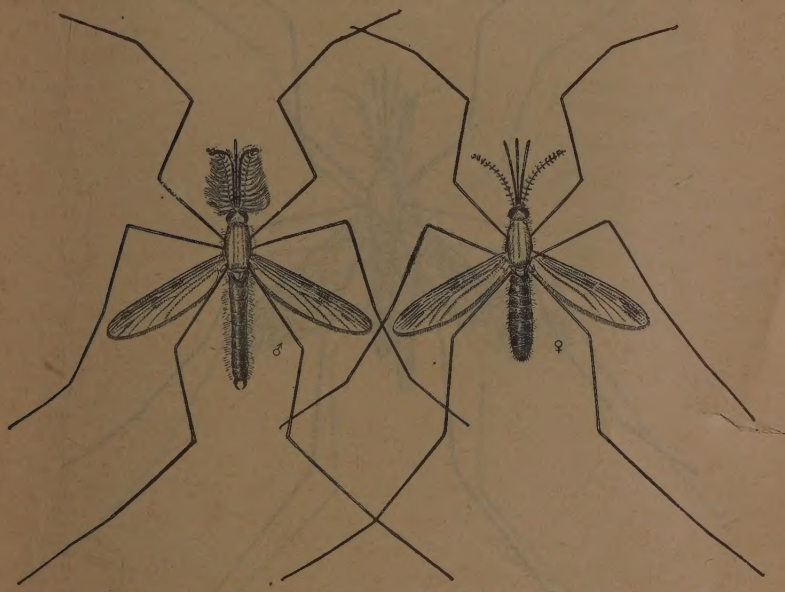

FIG. 1.—*Anopheles quadrimaculatus:* Male and female mosquitoes. Greatly enlarged. (Original.)

THE MALARIAL MOSQUITOES.

There are in the United States only three species of mosquitoes which commonly carry malaria, namely, *Anopheles quadrimaculatus* Say, *Anopheles crucians* Wied., and *Anopheles punctipennis* Say. Several other species of Anopheles are occasionally found, but are not important malarial factors.

Anopheles quadrimaculatus (figs. 1, 4, 5, 6) is commonly found in the more Northern States, and *A. crucians* (fig. 2) more abundantly in the Southern States, particularly in the coastal region.

A. punctipennis (fig. 3) occurs in both Northern and Southern States. It has been found to carry quartan and tertian malaria in

the South, but not in the North. A number of experiments have been made with this species in the North, and especially at Baltimore and New York, to see if it will carry malarial parasites, but without success.

The anopheline mosquitoes are distinguished from most other mosquitoes of the United States by the fact that their wings are more or less spotted, and that in resting on the wall their bodies incline away from the wall at an angle, while with most others the body is parallel

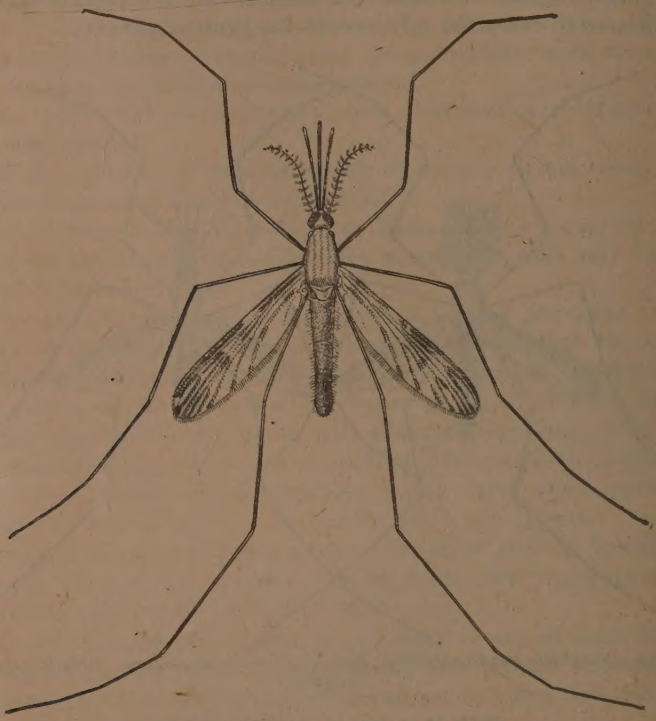

FIG. 2.—*Anopheles crucians:* Female mosquito. Greatly enlarged. (Original.)

to the wall. The females also have palpi which are nearly as long as the proboscis, or beak.

The Anopheles mosquitoes above mentioned pass the winter as adults. In the autumn they enter houses, stables, barns, or other outhouses, or seek other sheltered hiding places, and remain there until spring. They are often found in the winter in numbers in the cellars of houses, where they may be killed by fumigation.

These mosquitoes, as a rule, bite only after sundown. *Anopheles crucians* has on rare occasions been known to bite during the day, as

has *A. punctipennis.* This has not been recorded of *A. quadrimaculatus.*

They do not fly far. It is doubtful whether any of these species ever flies for more than half a mile.

These Anopheles mosquitoes breed in all sorts of accumulations of standing water, in pools, springs, watering troughs, in the footprints of cattle in marshy land, and in marshes where fish are not abundant, in drains and gutters choked with grass or weeds, in old boats along the waterfronts, in hollows in rocks, in the backwaters of

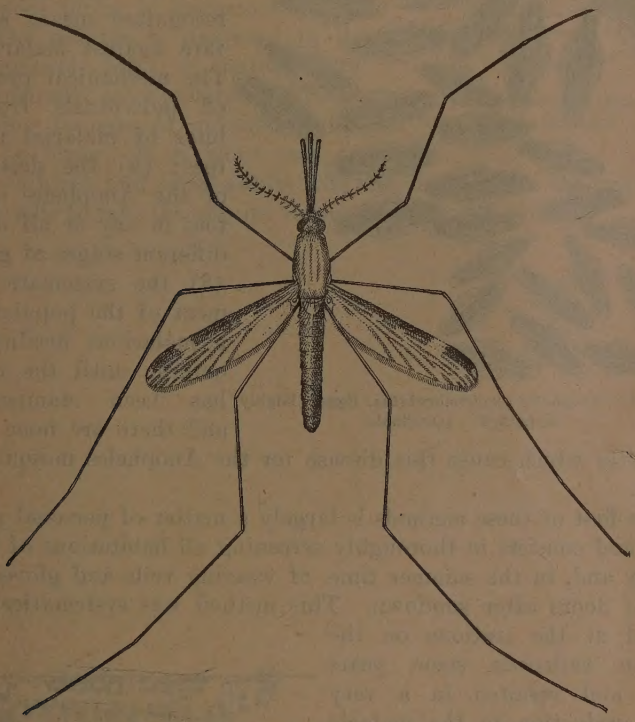

FIG. 3.—*Anopheles punctipennis:* Female mosquito. Greatly enlarged. (Original.)

even rapid streams, in earthenware vessels, in water barrels and tubs, in cesspools, and all places carrying water accumulations, whether pure or foul. *Anopheles crucians* and *A. quadrimaculatus* have even been found breeding in brackish water along the seacoast.

The minute, brackish eggs (fig. 4) are laid on the surface of the water and are found floating on their sides singly or in groups.

Their larvæ do not hang from the surface of the water by the tail, as do other mosquito larvæ or "wrigglers" when at rest, but lie flat at the surface, with their heads turned upside down, feeding upon minute floating particles, at or near the surface (fig. 5).

Their growth is rather rapid, and they may in midsummer reach full size in two weeks after hatching.

When full grown these larvæ transform to pupæ (fig. 6) and remain in this stage at the surface of the water for three or more days, when the adult mosquitoes issue.

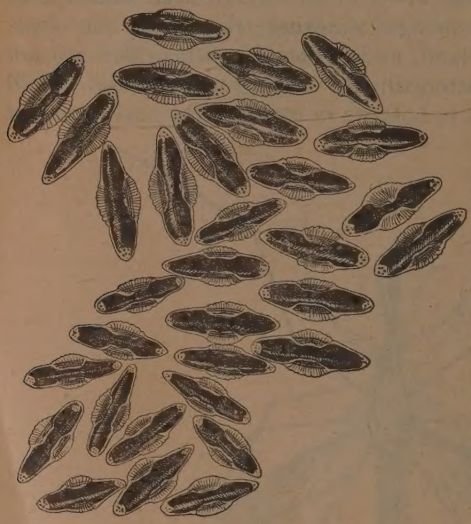

FIG. 4.—*Anopheles quadrimaculatus:* Eggs. Highly magnified. (Original.)

PREVENTION AND CURE.

There are now three recognized means of warfare against malaria: (1) The mechanical protection of individuals from the bites of malarial mosquitoes; (2) the destruction of the Anopheles mosquitoes in any or all of their different stages of growth; (3) the systematic treatment of the population of a malarious locality with quinine until the malaria has been stamped out and there are none of the parasites which cause this disease for the Anopheles mosquitoes to carry.

The first of these methods is largely a matter of personal prevention, and consists in thoroughly screening all habitations of human beings and, in the summer time, of wearing veils and gloves when out of doors after sundown. This method was systematically enforced at the stations on the Italian railroads some years since and resulted in a very great reduction in the malaria rate.

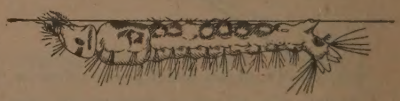

FIG. 5.—*Anopheles quadrimaculatus:* Larva in resting position. Greatly enlarged. (Original.)

The second measure, that of destroying the Anopheles, has been practiced with admirable success in Cuba, in Panama, in West Africa, in Egypt, and in certain localities in India. The measures of mosquito destruction used in these localities and elsewhere are described in a companion Farmers' Bulletin (No. 444).

The quininization method, or cinchonization method as it is called by the Germans and the Italians, has been used by the Germans in East Africa and by the Italians and, to some extent, by the English

in India. In Italy, by the means of mechanical protection, the malaria rate was reduced from 65 or 70 per cent down to 14 per cent, but here it held. The quininization method was then introduced, and the general malaria rate for Italy has by its means been reduced to less than 4 per cent.

FIG. 6.—*Anopheles quadrimaculatus*: Pupa. Greatly enlarged. (Original.)

This method consists in the distribution of free quinine to all laborers and to the poor living in malarious localities. The quinine is prepared in its most agreeable form, as confectionery and principally as chocolates, the latter containing tannate of quinine, which is not so bitter. It is more easy to induce children and those adults who can not tolerate the ordinary quinine salts to take the quinine in this form.

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